Space Weather Technical Forecast

Issued on Tuesday, 14 December 2021 at 13:19 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Slight chance of G1/Minor Geomagnetic Storms days 1-2 (14/15th). Potentially increasing solar activity.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity was Low, with increasing frequency of minor B class flares and one C1 flare at 14/0825UTC from a developing sunspot region AR2907 (S21E59 Dao/Beta). Two other regions are present, AR2905 (S11E25 Hax/Alpha) is dormant, whilst AR2906 (S29E33 Cai/Beta) is developing quickly. This cluster of sunspots in the southeast region of the disc will need close attention over the next few days, as new developments may increase the chances of flaring. No Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured at L1, was at slow background levels 300-330 km/s, whilst its density was mainly above average at 15-20 ppcc, recently dropping to 10ppcc. The Interplanetary Magnetic Field strength (IMF) Bt was mainly weak between 4 and 7nT. The Bz component was mainly positive yesterday but has since become mainly negative, with a brief maximum dip of -6nT measured by DSCOVR at 14/0050UTC. The Phi angle was mostly positive before flipping to mostly negative after midnight, suggesting a solar sector boundary crossing may have happened around then tying in with the negative Bz spike and high density. Geomagnetic activity was mainly Quiet (Kp 0-2).
Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) was at mainly Background levels with the associated 24-hour integrated fluence below the Active threshold. Fluence of 2.88e6 was observed at 14/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar Activity is expected to be Low with a (perhaps increasing) likelihood of further isolated C-class flares given the developing and increasing numbers of sunspot regions on the visible disc. The chance of M-class flares rises to 10% by day 4 assuming sunspot development continues at a similar rate.

Solar Wind / Geomagnetic Activity: Solar winds are likely to soon become slightly elevated due to the late arrival of the fast wind of CH34. A further enhancement to elevated levels is then anticipated during day 2 from the fast wind of CH32, only gradually easing later day 3 (16th) onward. Geomagnetic Activity is forecast to be Quiet for much of the rest of Day 1 (14th), potentially increasing to Unsettled with Active overnight into Day 2 (15th) with a slight chance of G1/Minor Storm. Activity should then decrease to Quiet to Unsettled (Kp1-3) by day 3 (16th), and through day 4 (17th). No Earthbound CMEs are currently expected.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels. The high energy electron flux (greater than 2 MeV) is expected to be Background to Moderate levels initially. The arrival of coronal hole fast winds has the potential to increase the flux with persistently High flux possible by day 3 and 4 (16th and

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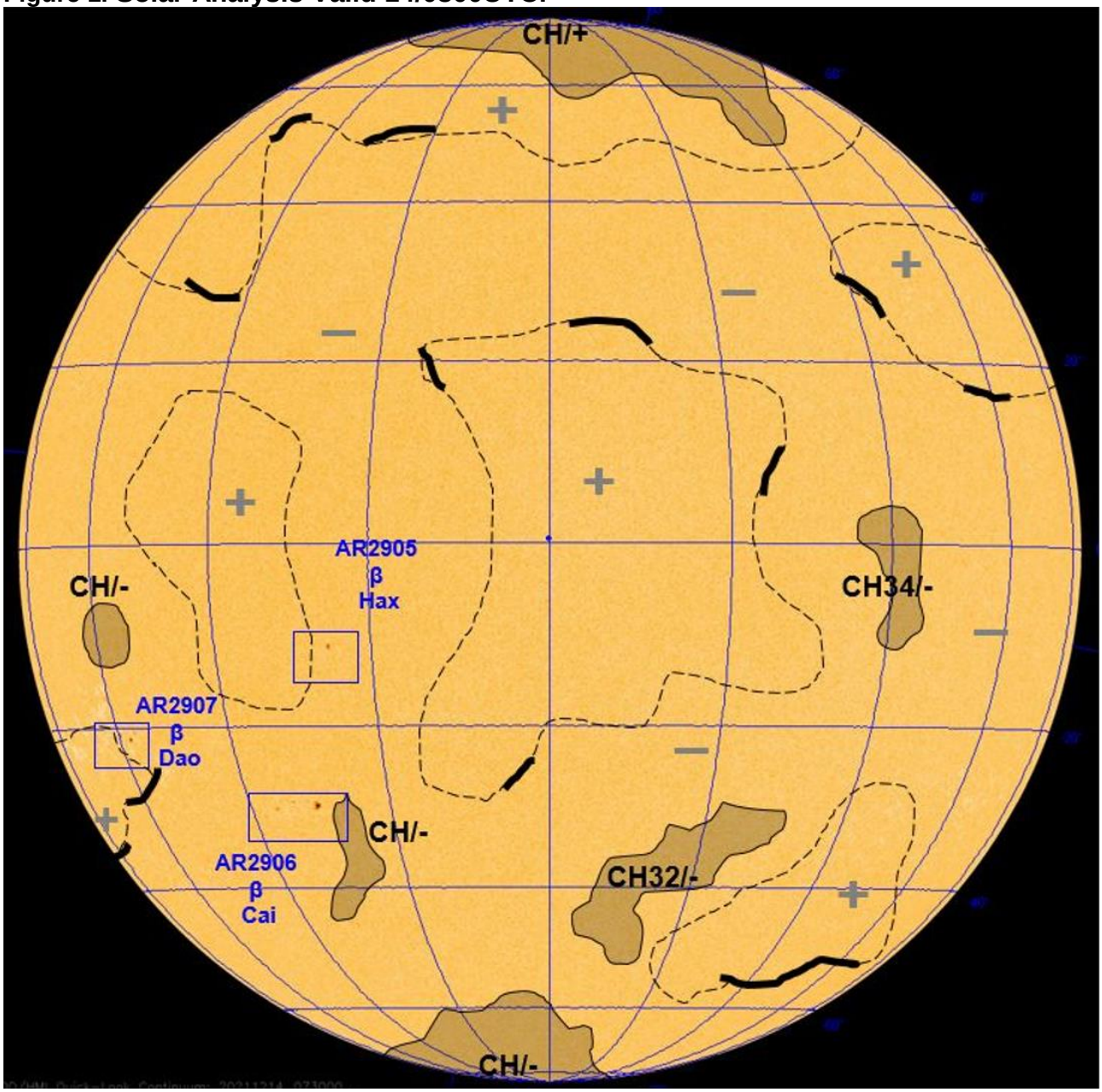
17th), although confidence remains Low for this. The associated 24 hour fluence is expected to persist below the Active level day 1 and day 2, but with an increasing chance of rising above by the end of day 3 and day 4 (16th and 17th) should the fast wind arrive.

Figure 1. Solar Analysis Valid 14/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs. Connection to coronal hole 34 has been slower to occur than previously anticipated, but still expected later today (14th). A transition into the fast wind of coronal hole 32 is then expected during day 2 (15th) although confidence is moderate on the timings. Elevated winds of around 500 km/s are then expected before gradually easing later day 3 (16th) onward.

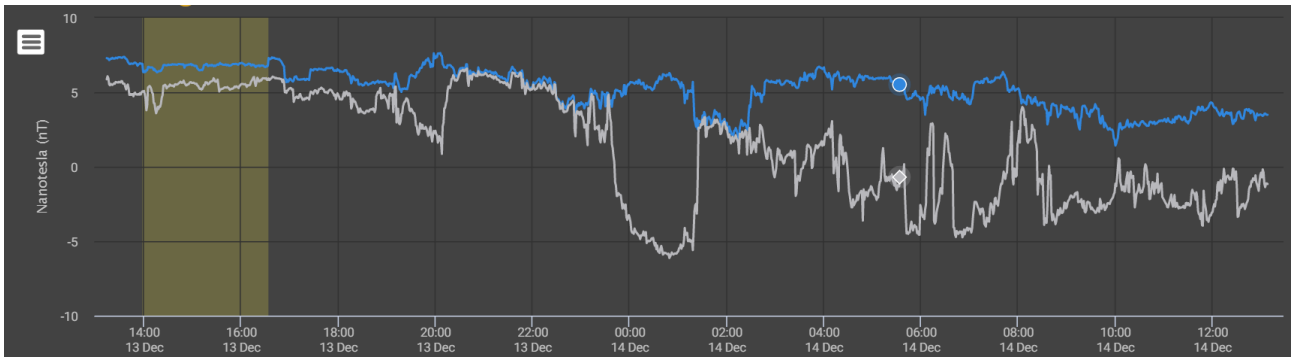
This is supported by Enlil, which has an enhancement day 2 (15th), although this doesn't have any notable increase to speeds from CH34. Persistence from the previous rotation is currently reflecting an earlier arrival of the wind which has yet to be observed. This may be because visually the coronal holes seem to have retreated eastward, as evident on a comparison of SDO AIA-193 imagery.

Maximum geomagnetic activity during the passage of the probably fast wind is likely to be G1 Minor Storm, although only a slight chance (20% risk) of this has been assessed. Geomagnetic activity will wane again after the peak period of fast wind experience into days 3 and 4 (16th and 17th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	15	20	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections – NONE EXPECTED

Figure 2: Current L1 DSCOVR SWEPAM IMF (Bt and Bz)



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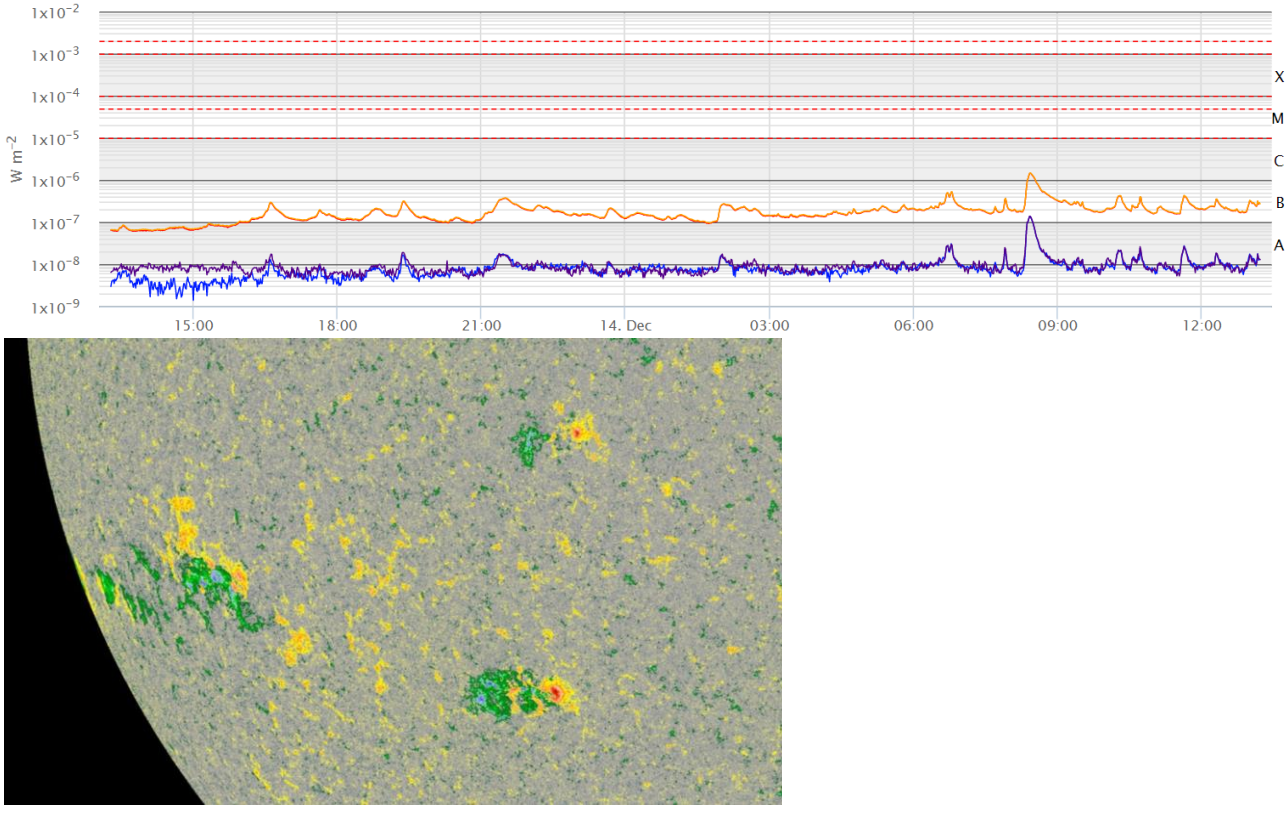
Radio Blackouts - X-Ray Flares:

There are currently 3 sunspot regions on the visible disc, two are growing. AR2905 (S11E25 Hax/Alpha) is currently dormant and insignificant. One C1 flare at 14/0825UTC was produced from developing region AR2907 (S21E59 Dao/Beta) which appears to be developing in a pre-existing plage field. This means it is more likely to become unstable and flare as pre-existing energy is released. Another region AR2906 (S29E33 Cai/Beta) is also developing quickly but this time in a clean field with no plage. This has given some B-class flaring during the last 24 hours which seems to be increasing. This cluster of sunspot regions and old plage will be carefully monitored over the coming days. For now, assuming continual development takes place, the probabilities of flares increases in the forecast period with 10% chance of M-class flares by Day 3. Further active regions are likely to rotate into view over the next week as suggested from the side-view of the Sun provided by Stereo A.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	2	5	10	10
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: Recent GOES16 Flare trace showing gradual increase in flux, and SDO HMI Sunspots



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is forecast to remain at background levels. Increasing sunspot activity may warrant a slight increase of chance of S1 over the next few days, but as the regions are in the east quadrant of the solar disc, any large flares are less likely to affect the Earth. They will become more of a risk when they move into the western quadrant.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	2	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as observed by GOES-16, is expected to be Background to Moderate levels initially. The arrival of the fast winds of CH34, and then CH32, through day 1 and 2 (14th and 15th), has the potential to increase the flux with persistently High flux possible by late day 3 or day 4 (15th or 16th), although confidence remains Low for this. The associated 24 hour fluence is expected to persist below the Active level day 1 and day 2, but with an increasing chance of rising above by the end of day 4. This is supported by REFM which maintains fluence below the Active threshold.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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